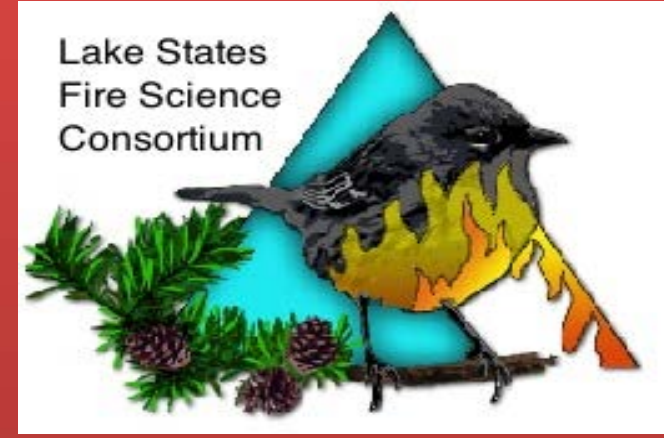


Fire affects vegetation composition in Great Lakes ecosystems



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Forest types Studied



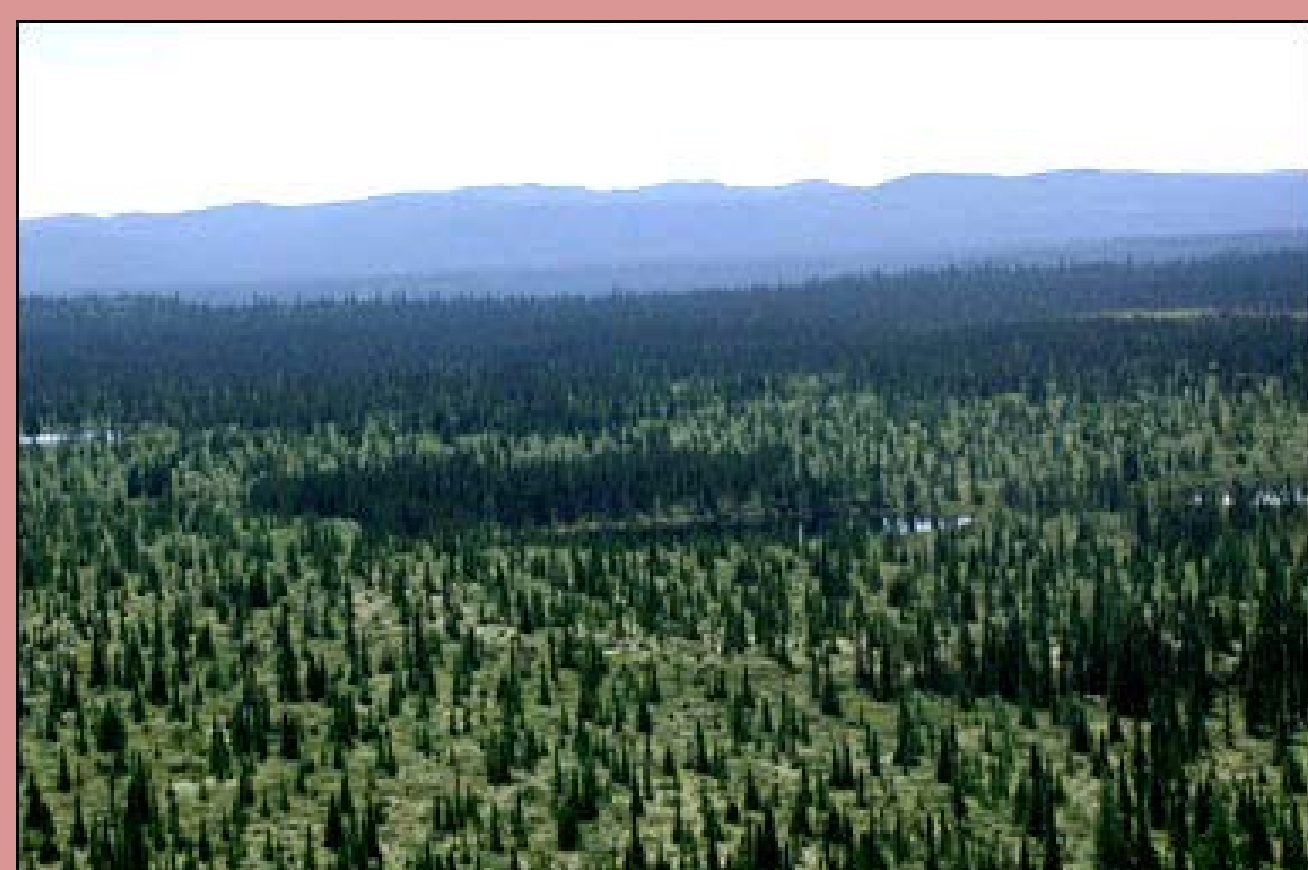
Oak Savanna

Oak forests and savanna are considered to be the most common deciduous species in North America. Oak forests can be found primarily in Wisconsin, but are also common in Michigan and Minnesota. The primary species found in oak forests are red oak (*Quercus rubra*), black oak (*Quercus velutina*), and some white oak (*Quercus alba*). (Photo from US Forest Service)



Jack Pine Stand

Jack pine (*Pinus banksiana*) stands are also common in the Great Lakes area, primarily in the upper midwest, such as Minnesota, Wisconsin, and Michigan. These consist mainly of Jack pine, but do also contain other *Pinus* species, such as the red pine (*Pinus resinosa*) and white pine (*Pinus strobus*). (Photo from Minnesota Public Radio)



Boreal Forest

The boreal forest is found in northern Minnesota and throughout most of Canada, stretching from British Columbia to Quebec. Young boreal forests consist primarily of jack pine (*Pinus banksiana*) and trembling aspen (*Populus tremuloides*), while older, more mature areas consist of black spruce (*Picea mariana*), white spruce (*Picea glauca*), and balsam fir (*Abies balsamea*). (Photo by National Resources Defense Council)

What is Fire Ecology?

- 1) Fire ecology is the study of how fire affects an ecosystem. Fire ecologists use this to study how fires start, how they spread, and how they affect the ecosystem.
- 2) Fire severity can be classified into three different categories, which are ground fires, surface fires, and crown fires.
- 3) Fire frequency involves how much fire occurs in an ecosystem in a given period of time.
- 4) Fire regime is defined by the frequency and severity of fires in a specific ecosystem

Methods

- Some keywords or terms used to look for articles included "vegetation composition," "post-fire composition," wildfire and jack pine, fire and boreal forests, and fire and oak forests.
- I classified each article based on whether fire had a positive impact on the ecosystem or no impact, regardless of the ecosystem type.
- In order to analyze the data, I performed a Chi-square test. The degree of freedom for this analysis of two categories was one. To determine a chi-square critical value for this study, I used an alpha level of 0.05, which set my critical value at 3.84.
- My null hypothesis was that the number of articles reporting positive effects of fire would be equal to the number of articles reporting negative effects of fire.

Results

Study	Location	Ecosystem Type	Positive or no effect?	Pre-fire vegetation-community	Post-fire vegetation-community	Fire-related measurements
Ahlgren, C. E. (1960)	Superior National Forest, Northeastern Minnesota	Boreal	Positive	All plots contained jack pine, with some plots consisting of black spruce, some aspen and some birch	Species varied per site because of the mineral concentration left by varying fire severity, burned plot produced most plants with seed reproduction, several species in the jack pine stands are fire tolerant, most species pre-fire survived and reproduced post-fire	Study fires occurred between 1952-1956, Fire severity categorized in three classes (ranked from least to most severe), 1. Light burn, 2. Hard burn, 3. Severe burn
Ehnes, J., & Keenan, V. (2002)	Throughout Canada	Boreal	Negative	Wide range of vegetation, focuses on overstory vegetation and on understory, high richness of Pinus species	broadscale trees and other trees with strong reproductive systems prospered, all others had a decline in composition percentage	ND
Hart, S. A., & Chen, H. Y. H. (2008)	north of Thunder Bay, Ontario	Boreal	Negative	Primarily jack pine and trembling aspen, plots divided into deciduous, conifer, and conifer dominant areas	Pine stands with fire or disturbance more frequently saw an increase in species, older pine stands saw a significant decrease, spruce stands saw a very significant decrease in species richness. Overall, species richness increased soon after disturbance and decreased several years afterwards	Time since fire ranged from 25-201 years depending on plot
Hunt, S. L., Gordon, A. M., Morris, D. M., & Marek, G. T. (2003)	Northern Ontario	Boreal	Positive	Primarily involves jack pine and black spruce plantations, understory vegetation relatively similar between spruce and jack pine plantations.	Aspen had highest regeneration rate, fire plot had highest stand density, herbaceous plants also prospered compared to mechanical treatments, more invasive species were found in fire plot in early post-fire years	Plots were only burned once due to naturally-occurring wildfires or prescribed burning many years ago, years vary, range from 1946-1956
Kemball, K. J., Wang, G. G., & Dang, Q. L. (2005)	Southeastern Manitoba	Boreal	Positive	Consisted of primarily balsam fir, white and black spruce, trembling aspen and jack pine also common pre-fire.	Overstory (<i>Picea mariana</i> or <i>Pinus banksiana</i>) was not really affected by low severity fires, understory becomes more diverse at first, but slowly returns to pre-fire composition, low severity fires brought in invasive species at first, but went away after prolonged absence of fire	Fire occurred in either 1987 or 1989
Locantini, N., Simard, M., Bergeron, Y., Larocque, A., Assong, H., & Richard, P. J. W. (2005)	Clay Belt of northeastern Ontario and northwestern Quebec, Canada	Boreal	Positive	Positive effect for herbaceous plants, negative effect for woody plants	Consists of various species of pinus, balsam fir, spruce, and aspen, low severity fires brought in invasive species at first, but went away after prolonged absence of fire	Decreasing in this area since 1850, average frequency of stands is 148 years, Fire severity characterized into high severity and low severity
Wang, G. G., & Su, J. (2002)	Southeastern Manitoba	Boreal	Positive	Boreal forest, primarily focused on black spruce and the aspen as an invader, pre-fire consisted of black spruce and some aspen	relative competition intensity increased in all disturbed plots, undisturbed experienced most overall competition increase, burned area experienced high competition intensity in the first years, but leveled off and decreased	Fire occurred in 1983, study conducted from that point until 1998, severity classified as high severity crown fire
Reich, P. B., Balken, P., Carlson, D., Frelich, L. E., Friedman, S. K., & Grigal, D. F. (2001)	Northeastern Minnesota	Boreal	Positive	Primarily Jack pine and black spruce for overstory cover; bryophytes and mosses of a large amount of herbaceous species, some aspen also found, measured old vs young stands	Spruce and aspen stands showed higher vascular diversity in old stands, jack pine showed no significant difference in herbaceous, but increase in woody species, Jack pine and aspen found higher overall richness of woody herbaceous	ND
Abrams, M. D., & Dickmann, D. I. (1982)	Northeast lower Michigan	Jack Pine stand	Positive	Pre-fire vegetation composition varied among sites, but all vascular plants were measured uniformly among sites	89 different species found on burned sites, 40 of them exclusive to burned sites, grasses and sedges showed high richness on burn site, trees and shrubs showed least richness, vegetation cover and diversity increased in the first 5 years after fire.	Fires occurred between 1979-1980, fire surveys conducted between 1-6 years after fire
Neumann, D. D., & Dickmann, D. I. (2001)	Southwestern lower Michigan	Jack Pine stand	Positive	Mainly consisted of red and white pine trees, divided into herbaceous and woody plants <1 m tall.	Overall, overstory was not really affected by surface fires, once burned plots contained high concentrations of invasive species, biennial burned plots have very thick undergrowth, once burned had higher composition of woody ground plants.	Fires occurred between 1979-1980, fire surveys conducted between 1-6 years after fire
Ohmann, L. F., & Grigal, D. F. (1979)	northeastern Minnesota	Jack Pine stand	Positive	Jack pine dominated overstory, black spruce also common, diverse understory	both woody and herbaceous had twice as many species in burned than unburned, species diversity increased for herbaceous, not as much in woody	Fire occurred in 1971, study occurred for several years afterwards until 1978; severity characterized as high severity crown fire
Paik, B., & Kastendick, D. (2009)	Northern Minnesota	Jack Pine stand	Negative	Conifer dominant area, several species of pinus, groups divided into Populus, B. papyrifera, mid-tolerant hardwoods, shade tolerant hardwoods, Pinus, and woody shrubs.	Pinus banksiana comprised 88 percent of the overstory basal area, <i>Abies balsamea</i> , <i>Acet. rubrum</i> and <i>Picea mariana</i> were identified as having been present prior to the fire. Fire decreased significantly after fire, shrubs and some hardwoods increased in density, as well as populus, B. papyrifera was almost eliminated, 12 years later, all groups except some hardwoods increased in density after fire.	Fire occurred in spring, 1997
Wang, G. G., & Kemball, K. J. (2011)	Southeastern Manitoba	Jack Pine stand	Positive	Trembling aspen, white spruce, black spruce, and balsam fir dominated these areas.	Jack pine and black spruce had high seedling mortality rates, seedlings in severely burned plots had larger diameter than litter burned or scorched, trembling aspen regenerated as dominant species, black and white spruce also regenerated at moderate rate	Fire occurred in 1999, Three severity classes (ranked from least to most severe), 1. scorched, 2. lightly burned, 3. severely burned
Wang, G. G., & Kemball, K. J. (2005)	Southeastern Manitoba	Mixed Pine stand	Positive	Herbaceous plants, (ie grasses and forbs), found as most frequent, with no difference among severity, percent cover of nonvascular plants increased with increasing severity, woody plants decreased with increasing severity	Mainly consisted of aspen, conifer, balsam fir, spruce, and aspen, low severity fires brought in invasive species at first, but went away after prolonged absence of fire	Fire occurred in 1999, study conducted over a 4 year period after the fire; Three severity classes (ranked from least to most severe), 1. scorched, 2. lightly burned, 3. severely burned
Wolf, J. (2006)	southeastern Wisconsin	Oak savanna	Positive	The dominant canopy tree species is <i>Quercus macrocarpa</i> , did not focus really on understory, <i>Quercus bicolor</i> Willd., <i>Q. rubra</i> L., <i>Q. alba</i> L., and <i>Q. velutina</i> Lam. are also present in various combinations with other species, measured canopy richness and percent cover for both overstory and understory.	High regeneration rates found in all frequencies, Oak was in more abundance in low frequency plots than high frequency, had higher spike in high frequency but did not stay long-term, both showed greater regeneration than unburned	High fire frequency-every 1-3 years, low fire frequency-every 4-6 years, unmanaged plots-no fire; Time since fire varied based on frequency, study conducted in 1980's
Rogers, D. A., Rooney, T. P., Olson, D., & Waller, D. M. (2008)	southern Wisconsin	Oak Savanna	Negative	Divided into tree, shrub, and herbaceous plants, northern pin oak and bur oak are dominant in this community.	Overall tree density decreased 16%, Quercus species declined significantly throughout the study, red oak experienced the greatest decline, found 15% decrease for understory vegetation	ND
Peterson, D. W., & Reich, P. B. (2001)	Cedar Creek Natural History Area, east-central Minnesota	Oak Savanna	Positive	Dominated canopy by red and bur oak, ground layer found to have many different species, some flowering and some not, no specific data regarding how much understory vegetation was present	Many new species regenerated in low-frequency plots, oak only found in high-frequency plots, tree density and size decreased with higher frequency.	Fire frequency characterized into high frequency (11-26 burns), low frequency (4 burns), or unburned; Fires initiated in 1964, study looks at vegetation results from 1984-1995
Bowles, M. L., Jacobs, K. A., & Mengler, J. L. (2007)	Northern Illinois	Oak savanna	Positive	Oak dominated forest with maple trees mixed within, half the sites included this, other half included all oak species, no specifics about herbaceous species mentioned	Overall basal area was higher than unburned plot, overall stem density was higher in unburned plot, found higher composition of understory woody species, some invasive species found primarily in burned plot	All plots burned once per year (usually conducted in fall); Fires occurred between 1986-2002.
Franklin, S. B., Robertson, P. A., & Fralish, J. S. (2003)	Kentucky and Tennessee	Oak Savanna	Positive	Oak dominated forest with maple trees mixed within, half the sites included this, other half included all oak species, no specifics about herbaceous species mentioned	Herbaceous species increased overall, fire also increased canopy cover, increased vertical growth of woody species, composition decreased if burned twice	Fire frequency-either burned once or twice, plots burned twice were burned in 1991 and 1993.
Fahrigandgenod, D., & Tester, J. R. (1993)	East-central Minnesota	Oak Savanna	Negative	No mention as to whether they studied herbaceous species or any other woody species	Significant decrease in all quercus species studied, no difference based on fire frequency, overall decrease in number of stems compared to unburned plots	Fire frequency-1.2 burns per year or 8.3 burns per year range; Fires conducted between 1964 and 1989

Purpose

- The purpose of this study was to determine how vegetation composition is affected by both prescribed and wild fires
- how are overstory and understory vegetation affected by fire of varying severity and frequency?
- how do specific types of plants regenerate after fire and any differences that may develop between the different forest types following fire?
- I hypothesized that the post-fire composition will have an increase in the number of species based on fire frequency and severity compared to the pre-fire vegetation composition.

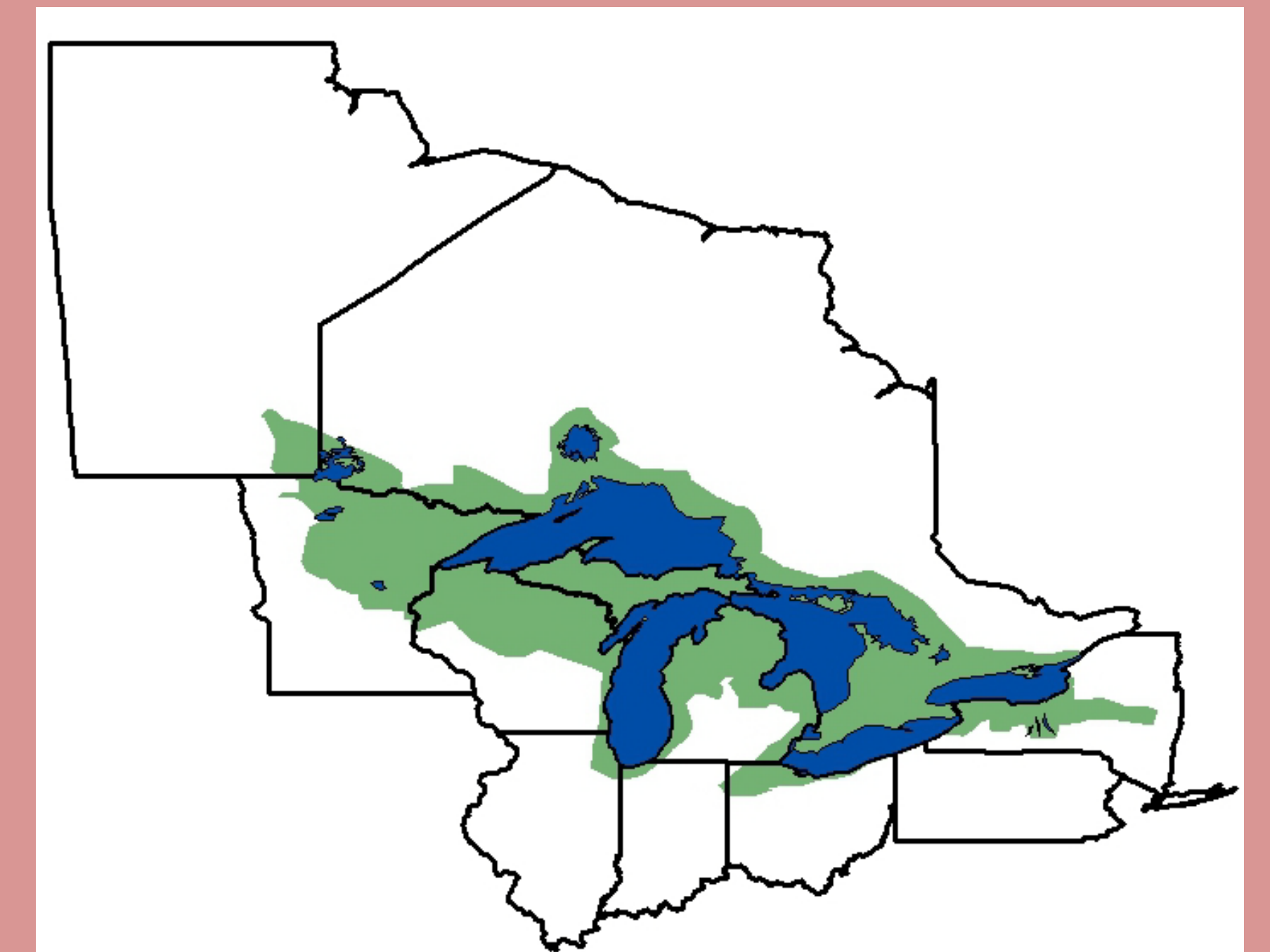


Figure 1. This is a map showing the Lake States Region. The area shaded in green is considered to be inside the region. Any study conducted within approximately 500 miles was also included.

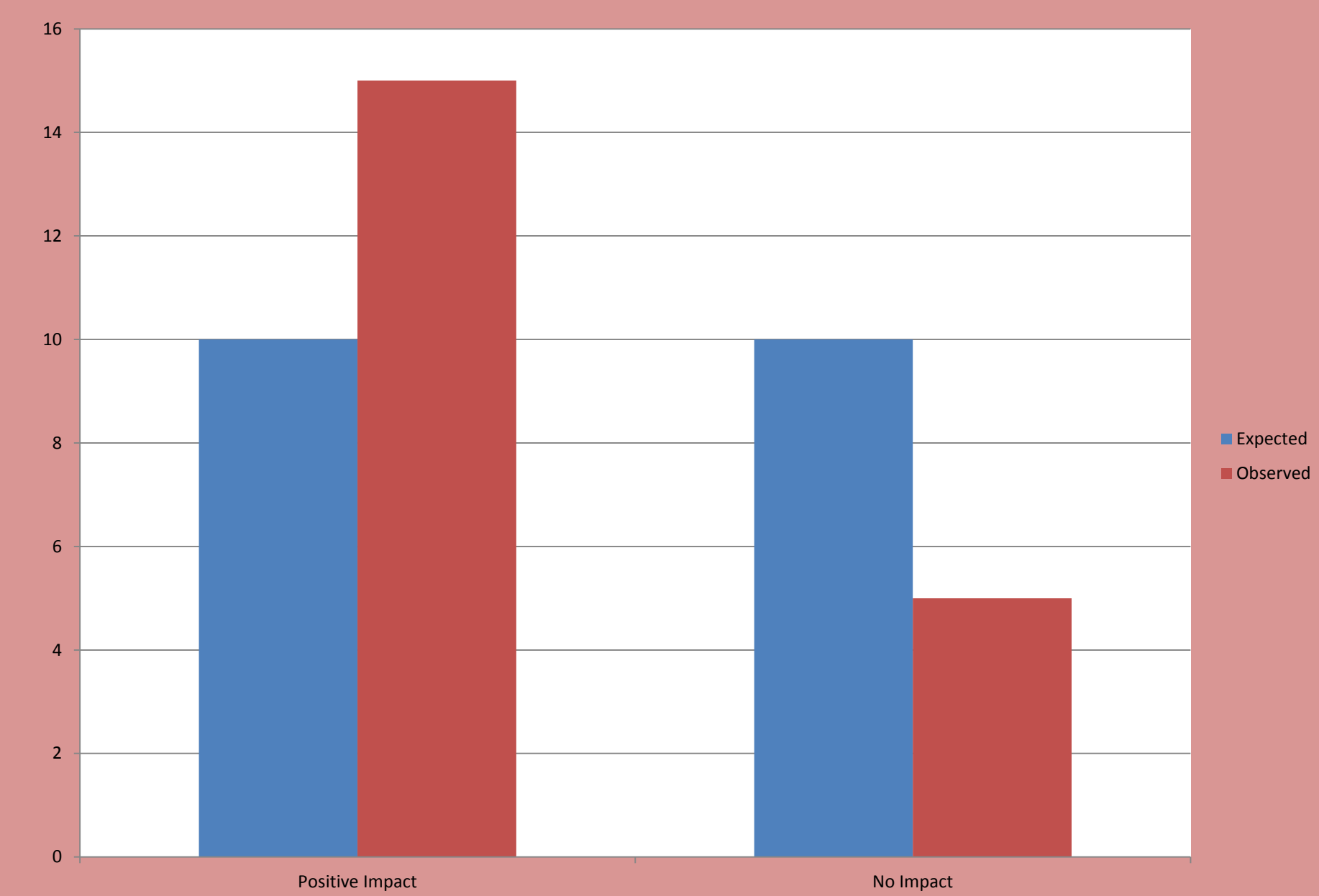


Figure 2. Bar graph shows the observed and expected responses of my chi-square analysis. The χ^2 value was 5.0, while the χ^2 critical value was 3.84, with a p-value of 0.05. Blue signifies expected results, while red signifies observed results. The left shows positive impact, while the right shows no impact.

- The keyword searches located 20 articles that addressed vegetation composition in the Lake States region.
- The overall trend within the articles favors a positive response to vegetation regeneration, with 15 articles showing a positive impact. The remaining five articles had a negative impact to fire, with two articles in the boreal forests, two in oak savanna, and one in jack pine stands (Figure 2).
- I found my chi-square value of 5.0 to be higher than the critical value of 3.84, which rejected my null hypothesis (Figure 2).
- Of the five studies that showed a negative response, only two studies found a negative impact for both woody and herbaceous species. Two of the articles that measured both herbaceous and woody species found that herbaceous species had a positive impact, while woody species had little to no impact.
- Overall, this research found many gaps in the amount of information relevant to the Great Lakes region, such as a limited amount of available research and the studies conducted on this topic in the region use a variety of methods, which limits comparability among studies.